UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND
TOXIC SUBSTANCES

MEMORANDUM

DATE:

SUBJECT: Biological and Economic Assessment of the Use of Diazinon on Almonds

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Summary

The standard annual diazinon plus oil dormant spray treatment regime controls two major pests of almonds--the peach twig borer and San Jose scale. Based on the effectiveness of the available pest management options, BEAD expects no yield or quality losses if diazinon were no longer available to growers.

Replacing this treatment regime with another conventional dormant OP plus oil spray regime, which essentially controls the same pests subject to some limitations, increases cost to growers by less than 1 percent and results in a total impact of less than $1 million. Replacing this standard treatment regime by regimes that exclude the use of other OPs and reduce or eliminate the use of diazinon increases costs and impacts the economy differently depending on pest pressure. Using basic regimes such as alternate-year dormant diazinon plus oil spray, Bt at bloom spray with dormant oil spray, and dormant non-OP plus oil spray necessitates the use of various in-season sprays to help control the peach twig borer and San Jose scale.

Depending on the alternate regime utilized and on the extent of pest pressure, increases to grower costs and total impacts vary accordingly. Under low pest pressure, the use of alternate-year diazinon or non-OP regimes increases cost to growers up to 2% and results in total impacts up to about $2 million. Under medium pest pressure, the corresponding cost increase range is 1% - 4% and the total impact range is $1 - $5 million. Under high pest pressure, the corresponding cost increase range is 3% - 6% and the total impact range is $4 - $8 million. These cost increases and impacts are short term (1 to 2 years), and may be largely eliminated over the longer time frame with market adjustments and the introduction of new chemicals.

Scope and Limitations of Assessment

The scope of this analysis includes an examination of potential regional-level impacts associated with elimination (through a phase-out) of the use of diazinon on almonds. This mitigation scenario is in response to the high health risks to mixers, loaders and applicators as identified by the Health Effects Division of the Office of Pesticide Programs. This analysis does not attempt to address impacts associated with mitigation efforts targeted at workers reentering fields treated with diazinon, or potential mitigation for various environmental risks (i.e., risk mitigation for risks to terrestrial plants and organisms or water contamination).

There are limitations to this assessment. The impacts estimated by this analysis only represent potential short-term – 1 to 2 year – impacts on the almond production system. Assumptions about alternative pest control measures associated with the various scenarios assessed in this analysis are based on the best professional judgement of BEAD analysts when estimates were not available from other sources. The basis for these assumptions is knowledge acquired from reviewing available USDA crop profiles, the Pest Management Strategic Plan for almonds, published studies, state crop production guides, discussions with university extension and research entomologists knowledgeable in almond production, and other sources listed. Production of almonds is a very complex system that can be affected by many parameters (e.g., weather). BEAD's ability to quantitatively capture the wide array of events that could unfold given each hypothetical scenario listed above is very limited. The economic analyses are based on crop budgets prepared by university extension specialists, which do not always include the exact combination of pesticides considered in BEAD's scenarios.

Crop Production Information -

Almond production in the United States takes place entirely within California, which also leads the world in production. In 2000, California produced 710 million pounds of almonds on 500,000 acres, valued at $852 million. Table 1 provides a three year average (1998 - 2000) of U.S. almond production statistics.

Table 1. U.S. Almond Production: Area, Production, and Value, 1998 Through 2000 (averages)

U.S./State	Bearing Acreage	Production (million pounds)	Percent of U.S. Production	Value of Production ($1,000)
California	480,000	688	100%	$748,000

Source: USDA/NASS Agricultural Statistics, 2001

The average orchard size is about 80 acres, with orchards typically varying in size between 20 and 400 acres. The majority of almond production occurs in the San Joaquin Valley with the Sacramento Valley being the other main producing region. Approximately 80 percent of the production is in the San Joaquin Valley. Kern and Fresno counties in the south and Merced and Stanislaus in the north are the highest producing counties in the San Joaquin Valley (USDA, 1999). Glenn, Butte, and Colusa counties in the Northern Sacramento Valley account for approximately 15 percent of the annual production in the state with the remainder being grown in the southern part of the Sacramento Valley. Other regions in the state account for <1 percent of the almond production (USDA, 1999).

The almond (*Prunus dulcis*) tree grows to about 40 feet, but is often kept at about 25 to 30 feet in commercial orchards because shorter trees with more branches are preferred for ease of operations. Although tree spacing may vary, mature orchard spacings are typically from 24 by 24 feet to 22 by 20 feet within and between the rows, with about 75 to 104 trees planted per acre. Young trees begin bearing fruit when three to four years old, producing full crops after reaching six to seven years of age. Almond trees may be productive for over 50 years although most orchards are removed at about 25 years of age (Micke, W.C., 1996).

Almond trees are dormant from November through January. Bloom through petal fall occurs from mid-February through mid-March. Honeybees pollinate the trees by transferring the pollen among the different cultivars, which are needed because almonds are not self-fertile. During post-bloom, which is from April through May, the nuts grow and develop. Throughout June the almonds harden. The hull, which is the outer fleshy material covering the shell of the nut, splits open in July (USDA, 1999; Integrated Pest Management for Almonds, 2nd Ed., 2002).

***Diazinon Use Patterns** -*

Table 2 lists the usage of diazinon on almonds in California. An average of 9% of California almond bearing acreage is treated with diazinon per year, and about 165,000 pounds of diazinon are applied (USDA/NASS, 2000). The average number of applications of diazinon per year in California is 1.2 with an application rate of 2.51 pounds per acre per application (USDA/NASS, 2000). It is most often applied with an airblast sprayer (90% of applications), however, approximately 10 percent of the applications are done by air (California Dept. of Pesticide Regulation, 2002).

Table 2. Usage of Diazinon on Almonds in California

U.S./State	Percent of Crop Treated	Base Acres Treated [1]	Total Pounds Applied (lbs)	Average Number of Applications (#/year)	Average Application Rate (lbs/acre)
California	9%	43,200	165,000	1.2	2.51

1. Base acres treated calculated using percent of crop treated estimates against bearing acreage from Table 1.
Source: USDA/NASS Agricultural Chemical Usage, 1999 Fruit and Nut Summary.

Historically, diazinon usage on almonds (and other tree crops) in California has been much higher than in recent years. Because of repeated detections of diazinon in various California surface waters and concerns for water quality, considerable efforts on the part of the state and county governments, municipalities, and growers has led to a marked decline in the amount of diazinon applied to almond orchards.

Target Pests -

The main target pests of dormant applications of diazinon on almonds are the peach twig borer (PTB) and San Jose scale (SJS). However, diazinon is also mentioned as a control for the European fruit lecanium (*Parthenolecanium corni*) (Integrated Pest Management for Almonds, 2nd Ed., 2002). Diazinon is only registered for use as a dormant or delayed dormant spray and is almost always mixed with petroleum oil which helps in the control of the SJS and is effective at controlling various mite species and other pests. A dormant spray application of an organophosphate insecticide together with petroleum oil is a key component of the almond IPM program for control of PTB, SJS and mites (Integrated Pest Management for Almonds, 2nd Ed., 2002). The Pest Management Strategic Plan for almonds lists the top five (5) research priorities for the almond industry. The control of PTB and SJS represent 2 of the top 5 research priorities (USDA, 2000).

For both of these pests, careful monitoring beginning in the dormant period and continuing through the growing season is important to determining if and when an insecticide application is necessary.

Peach Twig Borer

The PTB (*Arnasia lineatella*) is a major pest in almonds and other stone fruits. Native to Europe, the insect was first reported in California in the 1880s and is now found throughout the state. Until arrival of the navel orangeworm in the 1940s, PTB was the most serious pest of almonds. PTB damages almonds in two ways. First, by feeding in rapidly growing shoots (terminals) causing wilting and death of the shoot and, second, direct feeding on nutmeats causing them to be discarded creating the greatest economic damage. PTB damaged nuts also contribute to navel orangeworm (*Amyelois transitella*) problems later in the season making it even more imperative to control PTB from the outset.

Overwintered larvae begin emerging at about bud break and feed on young leaves and buds. As terminals elongate, maturing larvae establish themselves in a single shoot or terminal and mine the interior of the shoot. Adults also overwinter and emerge later in the season (April) when they oviposit on shoots or on developing fruit which can result in significant nut loss when populations are heavy. Additional generations occur (up to 4 per year) with each successive generations larvae feeding directly in the almond hulls or on the nutmeats potentially causing serious crop loss.

Diazinon is one of several insecticides that can be used to control the PTB. Of all the insecticides targeting this pest diazinon holds about 5% of the total market. In terms of total acre treatments, among all insecticides used to control the PTB, diazinon ranks sixth (Table 3). Some of these chemicals listed below would not (or can not) be used during the dormant period (see Appendix C for a description of the various alternatives to diazinon).

Table 3 also lists the percent of the almond crop treated with each active ingredient. For example, according to the National Agricultural Statistics Service, 18% of the almond crop was treated with *Bacillus thuringiensis* in 1999. Note that the percent of crop treated number covers all pests, and represents the percent of almond acres treated at least once, regardless of the target pest.

Table 3. Leading Insecticides Used for Control of the PTB.

Pest	Insecticide - Listed in Order of Importance (Based on Estimated Usage by Pest)[1]	Approximate Share of Total Insecticide Usage to Control the PTB	% Crop Treated (All Pests)[2]
Peach Twig Borer	1. *Bacillus thuringiensis*	30%	18%
	2. Chlorpyrifos	20%	17%
	3. Esfenvalerate	10%	14%
	4. Permethrin	10%	15%
	5. Petroleum Oil	10%	58%
	6. Diazinon	**5%**	**9%**
	7. Phosmet	5%	18%
	8. Spinosad	5%	5%
	9. Methidathion	< 5%	7%
	10. Azinphos-methyl	< 5%	7%

1. Importance based on the proportion of total insecticide usage (total acre treatments) for the control of the PTB. Target Pest Usage Data is based on EPA proprietary data.
2. Percent crop treated estimates are from USDA/NASS 1999 Fruit and Nut Summary, July 2000.

San Jose Scale

Dormant applications of diazinon are applied to almonds to also control SJS (*Quadraspidiotus perniciosus*). Scales cause damage by sucking plant juices from the inner bark of almond trees by inserting their mouthparts into twigs and branches. Infested branches stop growing and heavily infested branches and fruit spurs will die. The best time to control scale is during the dormant period or in early season after hatching until their armored covering is well developed. SJS have 3 to 5 generations per year in CA and heavy infestations may reduce production by as much as 10 percent if left uncontrolled (USDA Crop Profile, Jan.1999).

Most orchards do not have scale problems and will not require treatments specifically for this pest (UC IPM Guidelines, 2/2001). Monitoring is particularly important for this pest since infestations can build over time though resulting in damage to the tree. Populations of SJS have developed resistance to diazinon in the southern areas of the San Joaquin Valley, but it is still effective for scale control in other parts of the valley and the Sacramento Valley (Bentley and Connell, personal communication).

For SJS control, diazinon holds about 5% of the total market. In terms of total acre treatments, among all insecticides used to control the SJS and other scales, diazinon ranks sixth (Table 4). Table 4 also lists the percent of the almond crop treated with each active ingredient. Note that the percent of crop treated number covers all pests, and represents the percent of almond acres treated at least once, regardless of the target pest.

Table 4. Leading Insecticides Used for Control of the SJS and Other Scales

Pest	Insecticide - Listed in Order of Importance (Based on Estimated Usage by Pest)[1]	Approximate Share of Total Insecticide Usage to Control the SJS and Other Scales	% Crop Treated (All Pests)[2]
San Jose Scale and Other Scales	1. Petroleum Oil	60%	58%
	2. Methidathion	10%	7%
	3. Esfenvalerate	5%	14%
	4. Permethrin	5%	15%
	5. Chlorpyrifos	5%	17%
	6. Diazinon	**5%**	**9%**
	7. Propargite	5%	22%
	8. Spinosad	< 5%	5%
	9. Copper Sulfate	< 5%	-
	10. Phosmet	< 5%	18%

1. Importance based on the proportion of total insecticide usage (total acre treatments) for the control of the SJS and other scales. Target Pest Usage Data is based on EPA proprietary data.
2. Percent crop treated estimates are from USDA/NASS 1999 Fruit and Nut Summary, July 2000

***Alternatives to Diazinon* -**

Based on the effectiveness of the available pest management options, BEAD expects no yield or quality losses if diazinon were no longer available to growers. A brief description of each individual alternative pest control method currently available and considered in this analysis can be found in Appendix C.

California regulatory agencies and almond growers are concerned about diazinon (and other OPs) contamination in surface waters and have supported efforts to reduce levels of use through research on alternatives and educating users. Considerable effort has been extended researching alternatives to OP-based dormant applications. These efforts have led to significant reductions in use of OPs during the rainy season. Namely, during the period 1992 to 1997:

- the area of almond orchards treated with OPs during the dormant season was reduced by 40 – 55%, depending upon the region,
- the percent of growers who used OPs during the dormant season was reduced by 31 – 48%, and
- the total poundage of OPs applied to almond orchards during the dormant season was reduced by 22 – 57%. (Epstein et al., 2001).

Several publications and studies are available that detail pest management options to OP based dormant/delayed dormant treatments in almonds and stone fruits. A study by Zalom, et. al. (1999) is the basis for our review of the available alternative pest management strategies and the economic consequences of selecting an alternative treatment regime.

Based on the results of this study, the University of California Statewide Integrated Pest Management Project makes available to growers an online tool which estimates the costs of using organophosphate (OP) dormant sprays and selected alternative practices (http://www.ipm.ucdavis.edu/WATER/OPCALC/). According to the website, when compared to conventional OP dormant sprays, the alternatives listed in the calculator offer favorable levels of pest control efficacy with comparable ranges of cost.

The calculator is a useful tool for growers who are interested in estimating relative changes in their input costs associated with using the various treatment options included in the program. BEAD has utilized the alternative treatment regimes included in the program as the list of likely alternatives to a diazinon-based dormant/delayed dormant application. However, since the publication of this study, several new insecticides have become available that are not yet included as a part of this program. BEAD's analysis takes into account these new chemicals and the most recent available data.

There are 7 basic alternative treatment regimes identified by Zalom et al. (1999) to the conventional use of an annual dormant application of an OP (these include diazinon, chlorpyrifos, azinphos-methyl, methidathion, naled and phosmet) (see Appendix A). The practices included as alternatives to the OP plus oil dormant spray are considered to be those which are most viable and do not include all possibilities. Except for alternate year OP and oil dormant spraying (alternative #3), all of these alternatives have been the subject of University of California research and sufficient data exist to substantiate their viability according to the authors.

For the purpose of this analysis, several of the alternative treatment regimes were combined because of their similarities (Alternatives # 5 and 6 from the Zalom et al. study) or they were deemed to not be viable based on what is currently known about their effectiveness (Alternative # 7). Therefore, BEAD has considered 4 alternative treatment regimes:

- Alternative 1 - Conventional Dormant OP (other than Diazinon) Plus Oil Spray,
- Alternative 2 - Alternate-Year Dormant Application of Diazinon Plus Oil,
- Alternative 3 - Bloomtime Bt Sprays for PTB, Dormant Oil Applied, and
- Alternative 4 - Dormant Non-OP Plus Oil Spray

Key to any alternative treatment regimes is the careful monitoring of PTB and SJS populations in the orchard in order to predict and time applications targeted at these pests.

Alternative 1. Conventional dormant OP (other than Diazinon) Plus Oil Spray

It has long been recognized that the best time to use an OP insecticide (diazinon, chlorpyrifos, methidathion, phosmet, and others) and oil mixture for treating PTB and SJS on almonds is during the orchard dormancy period. Beneficial arthropods are less affected during the dormant period and certain other pests can also be controlled at that time. There is also better coverage of the bark for control of the overwintering larvae, scale, and eggs and less conflict with other cultural practices.

There are several other OP insecticides that growers could choose to use rather than diazinon at the dormant application, either phosmet, chlorpyrifos, azinphos-methyl, methidathion or naled.

Chlorpyrifos is the most used OP as a dormant spray. Chlorpyrifos is a good substitute for diazinon because it provides good efficacy on both PTB and SJS with substantially similar costs. However, it can not be used in the Sacramento Valley counties because of label restrictions. Azinphos-methyl currently has a 4-year time limited registration and is not currently recommended for use during the dormant period according to the 2001 UC IPM Pest Management Guidelines for almonds even though it is still a viable registered use. Methidathion will only control SJS and it can be used both as a dormant and in-season spray, but it is significantly more expensive than diazinon. Methidathion is also very disruptive to beneficial insects and is generally only recommended for use when SJS populations are quite high. Phosmet can also be used during both the dormant and in-season application timings. It is generally only effective on PTB and does not see much use during the dormant timing because of the effectiveness of diazinon and chlorpyrifos. Phosmet is currently most often used as an in-season spray to control navel orangeworm. Naled is rarely used and is only effective against the PTB. Naled can only be used as a dormant spray.

Without diazinon, the most likely OP-based alternative treatment regime would be a dormant/delayed dormant application of chlorpyrifos plus oil in the San Joaquin Valley which represents 80% of production. In the Sacramento Valley--where they can not use chlorpyrifos--the most likely alternative OP treatment would be methidathion plus oil.

Table 5.

Range of Likely Use Scenarios for Alternative #1*	
Alt #1 /A**	Chlorpyrifos + Supreme Oil + Application Costs (1) + PCA monitoring (80% of diazinon usage acreage - San Joaquin Valley)
	Methidathion + Supreme Oil + Application Costs (1) + PCA monitoring (20% of diazinon usage acreage - Sacramento Valley)
1 /B	Phosmet + Supreme Oil + Application Costs (1) + PCA monitoring
1 /C	Azinphos-methyl + Supreme Oil + Application Costs (1) + PCA monitoring
1 /D	Naled + Supreme Oil + Application Costs (1) + PCA monitoring

* All applications are made in Dormant period

** Alpha-numeric representation for Alternative #1 and scenario A, B, C or D

Alternative 2. Alternate-year Dormant Application of Diazinon Plus Oil

In concept, alternate-year application of conventional dormant pesticides should reduce potential environmental risks. Also, alternate-year applications should maintain populations of insect pests at densities lower than would be anticipated in the absence of any dormant sprays. According to UC IPM Farm Advisors Bentley and Connell (personal communication), this is becoming a much more common practice over the last several years and pest populations have not significantly increased.

In the year when no diazinon is applied, it is assumed that growers would still apply dormant oil which would provide control of low to moderate populations of SJS and overwintering mites and mite eggs. Monitoring for PTB and SJS is necessary in order to predict and time any in-season applications.

Several insecticides are available to growers for in-season control of PTB: spinosad, tebufenozide, esfenvalerate, permethrin, chlorpyrifos, phosmet, azinphos-methyl, and carbaryl. Several applications of these insecticides may be needed based on PTB populations and the number of generations usually experienced. PTB pheromone mating disruption is also available to growers, but it has seen very limited success in almonds (Bentley, personal communication).

Depending on which of these pest control methods are chosen disruption of beneficial insects and predatory mites that control pest mites will result in the need to apply additional acaracides. Acaracides available for use in almonds include fenbutatin oxide, clofentazine, propargite, abamectin, pyridaben, and sulfur.

Growers must also monitor for SJS. Due to the damage potential of SJS, annual oil sprays during the dormant or delayed dormant period should be considered to maintain populations at low levels if it is found chronically in an orchard. In orchards with low or moderate historical populations additional in-season applications may not be necessary following an oil only dormant application. Available in-season insecticides for SJS control include methidathion, chlorpyrifos, pyriproxyfen, and buprofezin.

Table 6.

Range of Likely Use Scenarios for Alternative #2*		
Alt #2 /Low**	**Yr. 1**	Dormant Diazinon + Supreme Oil + Application Costs (1) + PCA monitoring
	Yr. 2	Dormant Supreme Oil + Application Costs (1) + PCA monitoring
2 /Medium	**Yr. 1**	Dormant Diazinon + Supreme Oil + Application Costs (1) + PCA monitoring
	Yr. 2	Dormant Supreme Oil + Application Costs (1) + PCA monitoring In -Season - Esfenvalerate (for PTB) + Propargite (for mite control following use of synthetic pyrethroid) + Application Costs (1)

Range of Likely Use Scenarios for Alternative #2*		
2 /High	**Yr. 1**	Dormant Diazinon + Supreme Oil + Application Costs (1) + PCA monitoring
	Yr. 2	Dormant Supreme Oil + Application Costs (1) + PCA monitoring In -Season - Esfenvalerate (for PTB) + Propargite (for mite control following use of synthetic pyrethroid) + Application Costs (3)

* Not all possible alternative pest control measures are listed. BEAD has assumed that growers would choose the selected control measures under this Use Scenario based on current pesticide use patterns and current UC IPM pest control recommendations for these pests.
** Low/Medium/High - refers to pest pressure levels that could be experienced in Year 2.

Alternative 3. Bloomtime Bt Sprays for PTB, Dormant Oil Applied

Overwintering PTB larvae can be killed during bloom with well-timed treatments of *Bacillus thuringiensis* (Bt). This treatment is very selective and therefore not considered harmful to beneficial parasites or predators. However, because of its selectivity, Bt will not kill other pests like SJS that are normally controlled by the diazinon dormant spray. Approximately 86,000 acres of California almonds (18% of the crop) used this approach in 1999 (USDA/NASS, 2000).

In-season sprays may still be necessary for SJS with the absence of diazinon in the dormant application. The same in-season materials for SJS in Alternative #2 would be considered here. If necessary, the alternative chosen for SJS could also provide control of any PTB that escaped the bloom applications of Bt, namely chlorpyrifos or methidathion.

Table 7.

Range of Likely Use Scenarios for Alternative #3*	
Alt #3 /Low**	Dormant - Supreme Oil + Application Costs (1) + PCA monitoring Bt at Bloom (2 apps.) + Application Costs (1)***
3 /Medium	Dormant - Supreme Oil + Application Costs (1) + PCA monitoring Bloom - Bt (2 apps.) + Application Costs (1) In- Season - Pyriproxyfen (for SJS) + Application Costs (1)
3 /High	Dormant - Supreme Oil + Application Costs (1) + PCA monitoring Bloom - Bt (2 apps.) + Application Costs (1) In-Season - Chlorpyrifos (for SJS) (3 apps.)**** + Application Costs (3)

* Not all possible alternative pest control measures are listed. BEAD has assumed that growers would choose the selected control measures under this Use Scenario based on current pesticide use patterns for these pests.
** Low/Medium/High - refers to differing pest pressure levels that could be experienced.

*** Only one application cost is included because one of the Bt applications would be combined with an expected fungicide application.
**** 3 applications of Chlorpyrifos is assumed because of high pest pressure. Because multiple applications are necessary, BEAD believes growers would choose a cheaper SJS alternative (chlorpyrifos v. pyriproxyfen).

Alternative 4. Conventional Non-OP Pesticides Plus Oil as Dormant Spray

In-season sprays may still be necessary for SJS with the absence of diazinon in the dormant application. The same in-season materials for SJS in Alternative #2 would be considered here. If necessary, the alternative chosen for SJS will also provide control of any PTB that escaped the bloom applications of Bt.

Pesticides belonging to chemical classes other than OPs, including spinosad, synthetic pyrethroids (permethrin and esfenvalerate) and carbamates (carbaryl), have been used for control of PTB in the delayed-dormant or dormant season. Pyrethroid use in the dormant period has been increasing during the 1990s with a corresponding decrease in the amount of OPs applied (Epstein et al., 2000). None of these insecticides control SJS so in-season applications may be required (see Alternative #2).

Spinosad is a newly registered pesticide considered by the Agency to be reduced risk relative to the OPs and it is an effective PTB control material.

The pyrethroids are not as effective as the OP and oil spray in controlling scales during the dormant season. For this reason, additional in-season applications may be necessary for SJS control (see Alternative #2). Furthermore, residues of the pyrethroid insecticides permethrin and esfenvalerate persist on bark and may impact naturally occurring predator mites for extended periods of time after the dormant season and in-season applications. Mite outbreaks that result from the use of pyrethroids may require additional miticides, over and above those which may normally be applied, for their control (see Alternative #2).

Table 8.

Range of Likely Use Scenarios for Alternative #4*	
Alt. #4 /Low 1**	Dormant - Spinosad + Supreme Oil + Application Costs (1) + PCA monitoring In-Season - Chlorpyrifos + Application Costs (1) (for SJS)
4 /Low 2	Dormant - Esfenvalerate + Supreme Oil + Application Costs (1) + PCA monitoring In-Season - Chlorpyrifos (for SJS) + Application Costs (1)

Range of Likely Use Scenarios for Alternative #4*	
4 /Medium	Dormant - Esfenvalerate + Supreme Oil + Application Costs (1) + PCA monitoring In-Season - Chlorpyrifos (for SJS) (1 app.) + Application Costs (1) In-Season - Propargite (for mites) (1 app.) + Application Costs (1)
4 /High	Dormant - Esfenvalerate + Supreme Oil + Application Costs (1) + PCA monitoring In-Season - Chlorpyrifos (for SJS) (2 apps.) + Application Costs (2) In-Season - Propargite (for mites) (2 apps.) + Application Costs (2)

* Not all possible alternative pest control measures are listed. BEAD has assumed that growers would choose the selected control measures under this Use Scenario based on current pesticide use patterns for these pests.

** Low/Medium/High - refers to expected pest pressure

Economic Impact Assessment

The economic impact assessment of not having diazinon available as a dormant/delayed dormant application in almonds is based solely on estimated changes in pest management input costs. No yield or quality losses are expected when substituting the alternative pest control regimes previously described in this assessment for diazinon-based dormant applications.

Budgets for California Almonds

Main areas of almond production in California are the Sacramento Valley and the Northern San Joaquin Valley. A typical total cost of production for low-volume sprinkler irrigation in the Sacramento Valley for year 2001 was $1976/acre, where included harvest cost has been adjusted to reflect a yield of 1433 pounds (shelled-basis)/acre computed from data in Table 1. A typical total cost of production for sprinkler irrigation in the Northern San Joaquin Valley for 1998 was $2966/acre, also adjusted for a yield of 1433 pounds/acre, while corresponding total cost in that area for flood irrigation for 1998 was $2920/acre. Data are from the University of California Cooperative Extension, Department of Agricultural and Resource Economics. For the economic impact analysis, a total cost of $2944/acre, approximately midway between the given costs for sprinkler irrigation and for flood irrigation, is used in this impact assessment.

Impacts of Replacing Diazinon Treatments with Alternative Treatments

Cost impacts of replacing the standard dormant diazinon spray treatment (diazinon plus oil) with alternative treatments are given below in Table 9 each with respect to the various use scenarios (options) as defined in Tables 5 through 8. Estimated impacts included are cost impacts per acre, cost impacts relative to total production cost, and national impacts. Cost impacts are compared with production cost rather than with profit because the latter is less stable and predictable being a function of market prices, weather, and other factors. Impacts were computed using average chemical costs based on EPA data adjusted for application rates, estimated application costs of $25/acre for dormant sprays and $20/acre for in-season sprays (Zalom et al., 1999), estimated pest control advisor (PCA) monitoring costs of $25/acre per year (Zalom et al., 1999), total production cost of $2944/acre (see above), and total acres treated of 43,200 acres (Table 2). Details upon which Table 9 is based are given in the table of Appendix B.

Table 9. Impacts of Replacing Standard Annual Dormant Diazinon Treatment with Alternative Treatments

Treatment Alternative/ Option	Cost Change ($/acre)	Cost Change Relative to Production Cost (%)	Total National Impact ($1,000,000)
1/A - San Joaquin Valley	$2.05	0.1%	$0.1
1/A - Sacramento Valley	$18.35	0.6%	$0.2
1/B	$10.05	0.3%	$0.4
1/C	$2.15	0.1%	$0.1
1/D	$1.15	0.04%	$0.05
2/Low	-$4.17	-0.1%	-$0.2
2/Medium	$26.33	0.9%	$1.1
2/High	$87.33	3.0%	$3.8
3/Low	$33.35	1.1%	$1.4
3/Medium	$117.40	4.0%	$5.1
3/High	$146.75	5.0%	$6.3
4/Low 1	$55.85	1.9%	$2.4
4/Low 2	$37.95	1.3%	$1.6
4/Medium	$90.45	3.1%	$3.9
4/High	$180.75	6.1%	$7.8

Note 1 - See Appendix B for details of computations.

Note 2 - See Tables 5 through 8 for definitions of alternative treatments and use scenarios (options) which are summarized below. Low, medium and high refer to the levels of pest pressure.
Alt. 1 = Dormant OP (except diazinon) + oil spray, where A - Joaquin = chlorpyrifos, A - Sacramento = methidathion, B = phosmet, C = azinphos-methyl, and D = naled.
Alt. 2 = Alternate-year dormant diazinon + oil spray and dormant oil only spray (the latter with in-season esfenvalerate for PTB and propargite for mites as needed)
Alt. 3 = Bt at bloom for PTB and dormant oil spray (with in-season pyriproxyfen or chlorpyrifos for SJS as needed)
Alt. 4 = Dormant non-OP (spinosad or esfenvalerate) + oil spray (with in-season chlorpyrifos for SJS and propargite for mites as needed)

From Table 9, the cost impact per acre of alternative OP treatment varies from about $1 for naled-based treatment to $18 for methidathion-based treatment, each impact less than 1% of production cost, with corresponding national impacts each less than $0.5 million. Under low pest pressure, the cost impact per acre for non-OP treatment or alternate-year diazinon treatment varies from about -$4 for alternate-year diazinon-based treatment to $56 for dormant esfenvalerate-based treatment (the latter 1.9% of production cost), with total impacts up to $2.4 million. Under medium pest pressure, the corresponding impact per acre ranges from about $26 for alternate-year diazinon-based treatment (0.9% of production cost) to about $117 for bloom-time Bt-based treatment (4% of production cost), with total impacts from $1.1 to $5.1 million. Under high pest pressure, the corresponding impact per acre varies from about $87 for alternate-year diazinon-based treatment (3% of production cost) to about $181 for dormant esfenvalerate-based treatment (6.1% of production cost), with total impacts from $3.8 to $7.8 million, the latter which is still only about 1% of the total value of production of $748 million (Table 1).

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Appendix A.

Pest Management Practices Considered to be Most Viable by Zalom et al. (1999) *in* Alternatives to Chlorpyrifos and Diazinon Dormant Sprays - Final Report.

Option #1 - Conventional Dormant OP and Oil Spray

Option #2 - No Dormant Treatment with In-Season Sprays as Needed

Option #3 - Alternate Year Dormant Application

Option #4 - Bloomtime (Bt) Sprays for PTB

Option #5 - Spinosad as a Dormant Spray

Option #6 - Conventional Non-OP (Dormant) Pesticides

Option #7 - Pheromone Mating Disruption

Appendix B.

Impacts of Replacing Conventional Dormant Diazinon Spray Treatment with Alternative Treatments

Treatment Alternative/ Option	Chemicals	Chem Cost	Appl Cost	PCA Cost	Total Cost	Cost Chg from Baseline	% Chg in Prod Cost(1)	Total Impact(2)
		($/acre)	($/acre)	($/acre)	($/acre)	($/acre)	(%/acre)	(mill $)
Baseline	Diazinon + oil	$25.60	$25.00	$25.00	$75.60	-	-	-
1/A	Chlorpyrifos + oil (on 80% of acreage)	$27.65	$25.00	$25.00	$77.65	$2.05	0.1%	$0.1
1/A	Methidathion + oil (on 20% of acreage)	$43.95	$25.00	$25.00	$93.95	$18.35	0.6%	$0.2
1/B	Phosmet + oil	$35.65	$25.00	$25.00	$85.65	$10.05	0.3%	$0.4
1/C	Azinphos-methyl + oil	$27.75	$25.00	$25.00	$77.75	$2.15	0.1%	$0.1
1/D	Naled + oil	$26.75	$25.00	$25.00	$76.75	$1.15	0.04%	$0.05
2/Low	Yr 1 - Diazinon + oil	$25.60	$25.00	$25.00	$75.60			
	Yr 2 - Oil	$17.25	$25.00	$25.00	$67.25			
	2-Yr Average	$21.43	$25.00	$25.00	$71.43	($4.17)	-0.1%	($0.2)
2/Medium	Yr 1 - Diazinon + oil	$25.60	$25.00	$25.00	$75.60			
	Yr 2 - Oil	$17.25	$25.00	$25.00	$67.25			
	- Esfenvalerate + propargite	$41.00	$20.00	-	$61.00			
	2-Yr Average	$41.93	$35.00	$25.00	$101.93	$26.33	0.9%	$1.1
2/High	Yr 1 - Diazinon + oil	$25.60	$25.00	$25.00	$75.60			
	Yr 2 - Oil	$17.25	$25.00	$25.00	$67.25			

	- Esfenvalerate + propargite (3 appl)	$123.00	$60.00	-	$183.00		
	2-Yr Average	$82.93	$55.00	$25.00	$162.93	$87.33	3.0%
$3.8							
3/Low	Oil	$17.25	$25.00	$25.00	$67.25		
	Bt at bloom for PTB (2 appl, 1 w/fung)	$16.70	$25.00	-	$41.70		
	Total	$33.95	$50.00	$25.00	$108.95	$33.35	1.1%
$1.4							
3/Medium	Oil	$17.25	$25.00	$25.00	$67.25		
	Bt at bloom for PTB (2 appl, 1 w/fung)	$16.70	$25.00	-	$41.70		
	Pyriproxyfen for SJS	$64.05	$20.00	-	$84.05		
	Total	$98.00	$70.00	$25.00	$193.00	$117.40	4.0%
$5.1							

Impacts of Replacing Conventional Dormant Diazinon Spray Treatment with Alternative Treatments (Cont'd)

Treatment Alternative/ Option	Chemicals	Chem Cost	Appl Cost	PCA Cost	Total Cost	Cost Chg from Baseline	% Chg in Prod Cost(1)	Total Impact(2)
		($/acre)	($/acre)	($/acre)	($/acre)	($/acre)	(%/acre)	(mill $)
3/High	Oil	$17.25	$25.00	$25.00	$67.25			
	Bt at bloom for PTB (2 appl, 1 w/fung)	$16.70	$25.00	-	$41.70			
	Chlorpyrifos for SJS (3 appl)	$53.40	$60.00	-	$113.40			
	Total	$87.35	$110.00	$25.00	$222.35	$146.75	5.0%	$6.3
4/Low 1	Oil + spinosad	$43.65	$25.00	$25.00	$93.65			
	Chlorpyrifos for SJS	$17.80	$20.00	-	$37.80			
	Total	$61.45	$45.00	$25.00	$131.45	$55.85	1.9%	$2.4
4/Low 2	Oil + esfenvalerate	$25.75	$25.00	$25.00	$75.75			
	Chlorpyrifos for SJS	$17.80	$20.00	-	$37.80			
	Total	$43.55	$45.00	$25.00	$113.55	$37.95	1.3%	$1.6
4/Medium	Oil + esfenvalerate	$25.75	$25.00	$25.00	$75.75			
	Chlorpyrifos for SJS	$17.80	$20.00	-	$37.80			
	Propargite for mites	$32.50	$20.00	-	$52.50			
	Total	$76.05	$65.00	$25.00	$166.05	$90.45	3.1%	$3.9
4/High	Oil + esfenvalerate	$25.75	$25.00	$25.00	$75.75			
	Chlorpyrifos for SJS (2 appl)	$35.60	$40.00	-	$75.60			
	Propargite for mites (2 appl)	$65.00	$40.00	-	$105.00			
	Total	$126.35	$105.00	$25.00	$256.35	$180.75	6.1%	$7.8

(1) Based on estimated total production cost for almonds of $2944/acre. Cost impacts are compared with total production cost rather than with profits because the latter are less stable and predictable being reflective of market trends.
(2) Based on 43,200 acres treated with diazinon from Table 2.

Definitions:

Baseline = Dormant diazinon + oil spray
Treatment alternative 1 = Dormant OP (except diazinon) + oil spray
Treatment alternative 2 = Alternate-year dormant diazinon + oil spray with oil only spray (and in-season sprays when needed)
Treatment alternative 3 = Dormant oil spray + Bt at bloom sprays for PTB (and in-season sprays for SJS when needed)
Treatment alternative 4 = Dormant non-OP + oil spray (and in-season sprays for SJS and mites when needed)
PCA = pest control advisor. For computations, PCA costs are allocated to dormant phase.
PTB = peach twig borer.
SJS = San Jose scale.

Sources: Chemical costs are from EPA data adjusted for application rates, while application costs and PCA monitoring costs are

based on Zalom et al., 1999.

Appendix C.

Currently Available Pest Control Methods for Control of PTB and SJS in Almonds.

- Dormant Oils - 0 days PHI. Applied during dormant period to 58% of the acreage at the average rate of 3.5 gallons per acre (USDA/NASS, 1999). Oil alone can be effective in controlling low to moderate populations of SJS, but it does not control PTB. Must be applied with other insecticides for control of PTB and high populations of SJS. Often mixed with other materials applied during dormant/delayed dormant period. Will also control overwintering mite eggs. Do not use oil on water-stressed trees or injury can occur.

- Chlorpyrifos (OP) - 14 days PHI. Historically, this material is used as a dormant spray (single app.) for control of PTB and SJS, but it can also be used in-season (up to 3 apps.). Also commonly used to control ants on the orchard floor. Applied to 17% of the acreage in CA (USDA/NASS, 1999). Cannot be used during the dormant period in the Sacramento Valley because damage to trees can result. Will also control lepidopterous pests when used post-bloom.

- Methidathion (OP) - 80 days PHI. The most effective material for armored scales. Applied primarily during the dormant period to 7% of the acres (USDA/NASS, 1999), but can also be used in-season. Only one application allowed per year at each timing. Not generally effective for PTB by itself. Disruptive to biological control of mites if used during the growing season. In-season sprays may be phytotoxic to some almond varieties.

- Azinphos-methyl (OP) - 28 days PHI. Used on 7% of the CA acreage in 1999 (USDA/NASS). 4-Year time limited reregistration, therefore, future use is in question. Can be used during dormant period and in-season, however, it is used mostly in-season for navel orangeworm and PTB. Not effective for SJS control.

- Phosmet (OP) - 30 days PHI. Effective on navel orangeworm, PTB and other lepidoptera when used during growing season. Also used dormant for PTB, although it generally is considered not as efficacious as other materials applied during the dormant period. It will control SJS crawlers if they are present. Phosmet can only be applied twice per growing season as a foliar spray. It was applied to 18% of the acres in 1999 (USDA/NASS). Phosmet can cause mite outbreaks but is not as disruptive as some other materials.

- Naled (OP) - 4 days PHI. Applied only during the dormant/delayed dormant period by ground. No reported usage in 1999 by USDA/NASS. Not listed in 2001 UC IPM Pest Management Guidelines. Generally considered an ineffective material for PTB and provides no control of SJS (Bentley and Connell, 2002).

- Carbaryl (carbamate) - 0 days PHI. Can be applied in dormant period, but is more likely to be used mid-season. A useful material because it can be applied in an emergency situation up to 1 day prior to harvest. Effective on navel orangeworm, PTB and other lepidopterous pests. It will also control SJS crawlers and eriophyid mites. Carbaryl is extremely disruptive to natural enemies and will generally cause mite outbreaks. It is also very toxic to honeybees (USDA Crop Profile, 1999).

- *Bacillus thuringiensis* - 0 days PHI. Applied by ground or air to 18% of the acreage. It is used primarily for PTB control although it can control other Lepidoptera species if present. Does not control SJS. Timing of applications is critical and is often not effective during cold, wet springs. Recommendations from UC IPM Pest Management Guidelines is to make two applications during bloom to achieve adequate PTB control.

- Spinosad (fermentation product)- 14 days PHI. Applied as a dormant or in-season spray to 5% of acreage in 1999 (USDA/NASS). Usage is estimated to be increasing. Only effective against PTB; no SJS control. Concern about resistance developing following repeated use. Not disruptive of beneficial populations and existing mite IPM programs, however, it is highly toxic to bees.

- Esfenvalerate (synthetic pyrethroid) - 21 days PHI. Applied as a dormant or in-season spray on 14% of the acreage in 1999 (USDA/NASS). This is a highly effective PTB material when applied by ground during the dormant period. It does not control SJS. This is the most economical material available and has low mammalian toxicity. The biggest drawback is it disrupts biological control of mites, often even when applied during dormancy. If used during the growing season this material is very disruptive to the biological control of mites and should only be used during the growing season in an emergency situation. Use in-season will likely result in need to apply additional miticides. Resistance has developed in some growing areas to esfenvalerate (USDA Crop Profile, 1999). Not listed in 2001 UC IPM Pest Management Guidelines for PTB.

- Permethrin (synthetic pyrethroid) - 7 days PHI. Applied as a dormant or in-season spray to 15% of the acreage in 1999 (USDA/NASS) for PTB control. All other information same as esfenvalerate.

- Pyriproxyfen (IGR) - 21 days PHI. Recently registered for use; use statistics are not available. Applied as a dormant or in-season spray primarily for SJS control. Label claims suppression of PTB. Concerns about development of resistance following repeated use.

- Buprofezin (IGR) - 60 days PHI. Recently registered for use; use statistics are not available. Applied as an in-season spray only for SJS control. Apply no more than one application per season. Concerns about development of resistance following repeated use.

- Tebufenozide (IGR) - 14 days PHI. Recently registered for use; use statistics are not available. Applied during bloom period and/or in-season for control of PTB and navel orangeworm. Label recommends making 1 - 2 applications during the bloom to petal fall period depending on infestation level.

- Pheromone Mating Disruption - 0 days PHI. Mating disruption (MD) is only available for the PTB. According to the 2001 UC IPM Pest Management Guidelines, PTB MD with sex pheromones has been used successfully in almond orchards. However, research is currently under way to improve the reliability of the technique and methods of application (Integrated Pest Management for Almonds, 2nd edition, 2002). This method is most effective in orchards with low moth populations that are not close to other untreated PTB hosts. Walter Bentley, UC IPM Farm Advisor, indicates that PTB MD in almonds has not been successful (nor widely adopted as it has been in other tree fruits) because of the high costs of the program for almond growers (both product and labor to place dispensers) and difficulty in achieving adequate control.